Space Weather Technical Forecast

Issued on Sunday, 02 July 2023 at 01:32 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Chance of Isolated R1/R2 Radio Blackouts. Chance of G1/Minor Geomagnetic Storm intervals 04 Jul. Active Fluence expected throughout.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity is Moderate with X-ray activity at GOES16 showing occasional low-level C-class flares. An M-class flare occurred late in the period, reaching M1.1 at 01/2223UTC and originated from newly numbered region AR3359 in the far southeast. AR3354 in the northwest quadrant.is by far the largest and most magnetically complex on the Earth-facing side of the Sun, and currently shows as an Fhc/Beta-Gamma-Delta composition. The group has elongated slightly through the period, with a small overall decrease in penumbral area in the intermediate portion of the group, but it retains a Mt Wilson delta spot. The remaining sunspots, six numbered and one unnumbered are considerably smaller, weaker and magnetically simple. No Earth directed CMEs have been visible in available imagery.

Solar Wind / Geomagnetic Activity: The solar wind, as observed by DSCOVR at L1, indicates a weak connection to coronal hole 18 in the southwest quadrant, as the phi angle has been mostly positive (away from the Sun) throughout. The solar wind speed was initially near Elevated levels around 500km/s then slowly declining to around 450km/s (Slightly Elevated). The solar wind density was above average at times, peaking at 14 ppcc at 01/1611 UTC, otherwise density was most near average levels. The IMF was weak throughout, 7 nT or below, while the Bz was weak, and mainly positive. Geomagnetic activity was Quiet to Unsettled (Kp 1-3).

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV), as observed by GOES16, was at Background levels.
High energy electron flux (greater than 2MeV) was at Moderate to High levels, peaking at 2570pfu at 01/1650 UTC. The 24-hour integrated fluence has been on mostly level trend, reaching the Active threshold at 01/1200 UTC. A fluence of 1.29e8 was recorded at 02/0000 UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Low activity is expected, with a chance of reaching Moderate levels given isolated Moderate-class flares. This risk mostly coming from the large sunspot in the northwest at first, but also enhanced by new or returning regions through the forecast period.

Solar Wind / Geomagnetic Activity: A CME associated with a M3.8 flare on the 29 Jun may affect Earth as a glancing blow on day 3 (04 Jul). In the absence of any CME activity, the current slightly elevated fast wind from CH18/+ should slowly decline in the coming days. A connection to small CH20/- may occur on day 3 (04 Jul), however, any enhancements from this are expected to be weak, though may combine with the 29 Jun CME. Predominantly Quiet (Kp 0-2) geomagnetic activity is expected through the period, with activity probably becoming Unsettled (Kp 3) or Active (Kp 4) with any CME or high-speed stream arrivals. There is a chance of

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isolated G1/Minor Storm intervals on day 3 for CME or combined CME and high-speed stream effects, however confidence is rather low.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is most likely to remain at Background levels, but with a daily slight chance of reaching the S1/Minor Storm level, mainly due to AR3354.
High energy electron flux (greater than 2MeV) is expected to remain at diurnally Moderate to High levels (above 1000 pfu) in the coming days, unless the CME that left the sun on 29 Jun arrives at Earth, or connection to a weak high-speed stream occurs and geomagnetic activity subsequently increases. The corresponding fluence is now above the Active (1e8 integrated flux) threshold and likely to remain close to or above until any significant geomagnetic activity from CME or high-speed stream influences occur. From day 2 (3rd July) the electron flux diurnal peaks should gradually reduce, with a falling probability of continuing to exceed the Active threshold.

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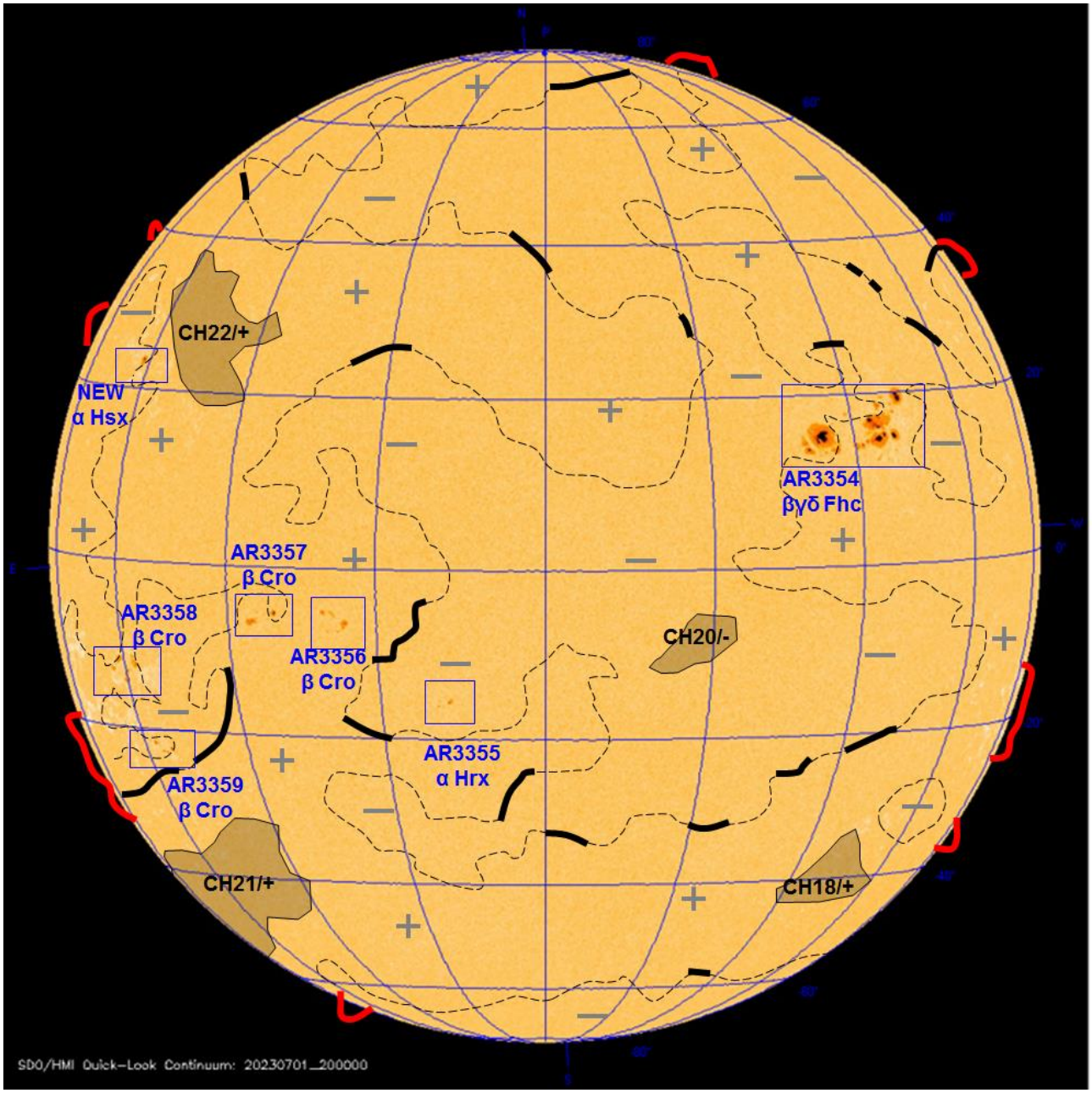
Figure 1. Solar Analysis Valid 2000UTC, 01 July 2023.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

A CME that left the northeast quadrant of the Sun on 27 Jun may glance Earth early on day 2 (02 Jul). However as it is already delayed then this indicates a very slow speed, and therefore the CME is likely to have less of a geomagnetic impact. A second CME, associated with the M3.8 flare from AR3354 on 29 Jun, may have an Earth-directed component. However, confidence for this CME is lower compared to the one from the 27 Jun, with the CME potentially arriving on day 3 (04 Jul). Currently slightly elevated solar winds from the fast wind of CH18/+ should slowly decline in the coming days. A connection to small CH20/- may occur on day 3, however, any enhancements from this are expected to be weak, although may occur at a similar time to the arrival of the 29 Jun CME. Otherwise no new or recurrent coronal holes feature in the period. It is therefore very possible, given the uncertainty of the CME arrivals, that the current fast wind from CH18/+ continues undisturbed until it naturally declines or is replaced by the onset of CH20/-. If this is the case then predominantly Quiet (Kp 0-2) geomagnetic activity is expected through the period, with activity probably becoming Unsettled (Kp 3) or Active (Kp 4) with any CME or high-speed stream arrivals on Day 3. There is a chance of isolated G1/Minor Storm intervals on day 3 for CME or combined CME and high-speed stream effects.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	5	1	20	1
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
28/0336	Partial	Filament Eruption	NE quadrant	600 km/s	01/1200 UTC +/- 12hrs	Glancing impact with low confidence
29/1415	Partial	Flare	North centre disc	762 km/s	04/0600 UTC	Extreme glance possible

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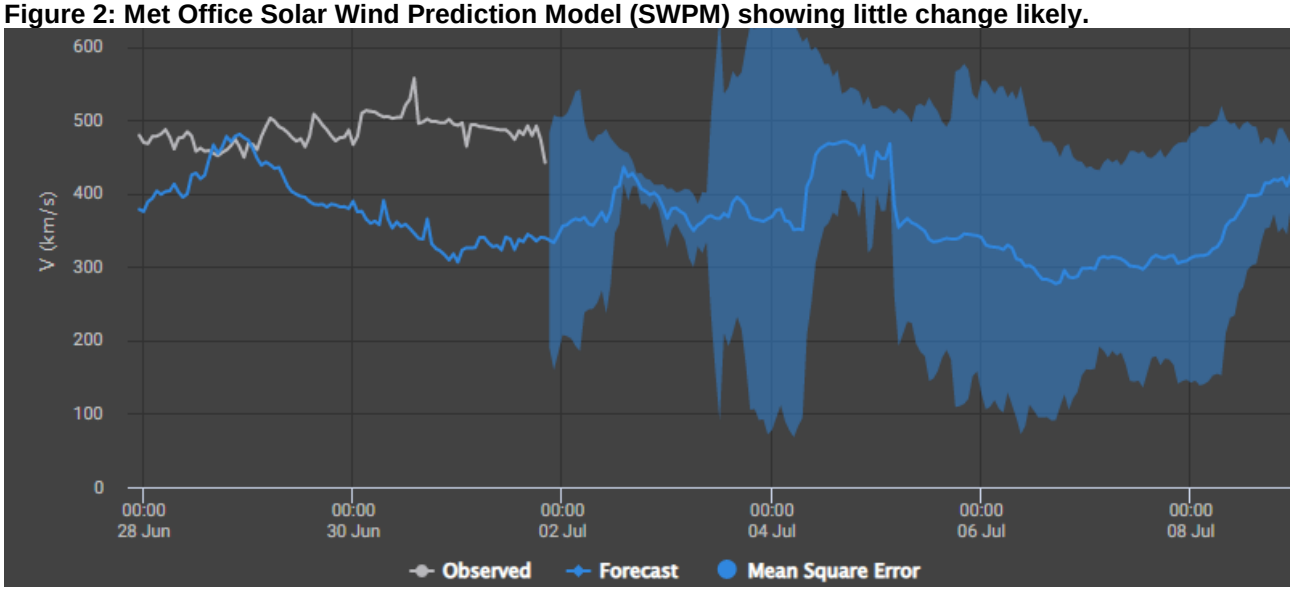
Figure 2: Met Office Solar Wind Prediction Model (SWPM) showing little change likely.



Radio Blackouts - X-Ray Flares:

Solar activity is Moderate with the largest flare of the period reaching M1.1 at 01/2223 UTC from a newly numbered region in the southeast, AR3358. There are seven sunspot regions on the visible disc, six of which are numbered. Of these AR3354, located in the northwest quadrant, remains by far the largest and most complex region, with a Mt Wilson delta spot. It has gradually elongated over the past 24 hours, as well as displaying a slight reduction in penumbral area in the intermediate portion of the group. The remaining spots are small, simple and stable, with most of these located in the eastern hemisphere. Over the coming days mostly Low solar activity is expected with a chance of Moderate levels at times given any isolated M-class flares, and there's also a slight chance of X-class flares. This risk is almost entirely from AR3354 at first, but may be enhanced by new or returning regions through the forecast period.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	40	40	40	40
Very Active	R3 to R5 X Class	No	5	5	5	5

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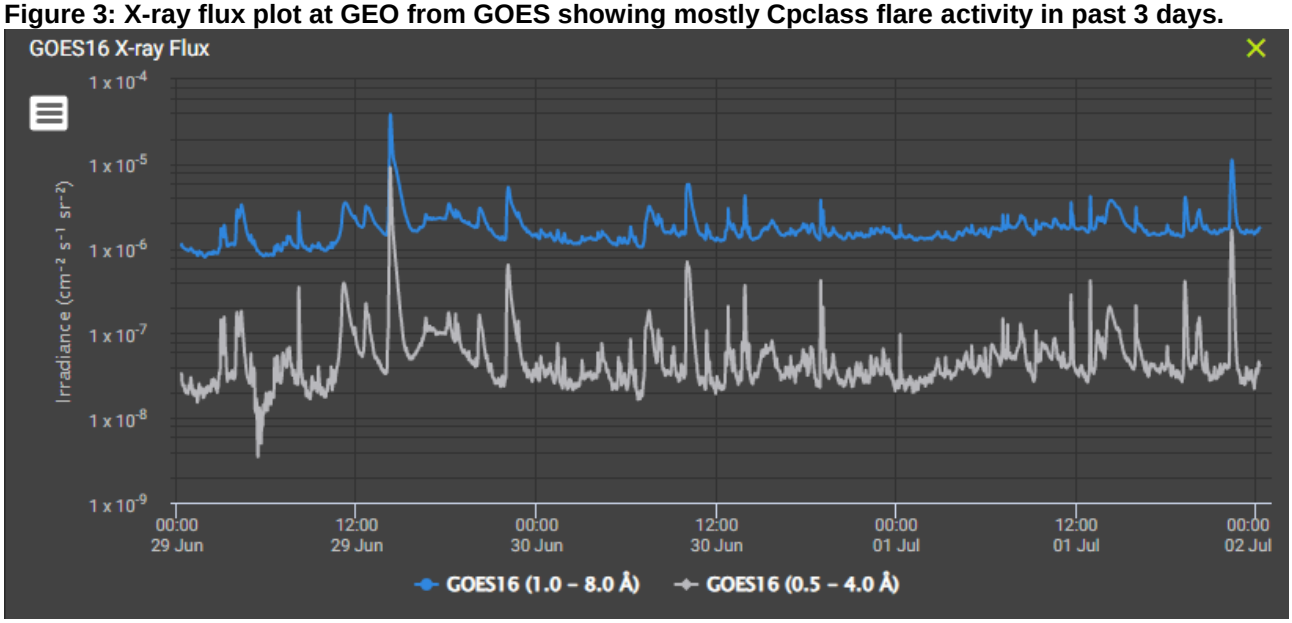
Figure 3: X-ray flux plot at GEO from GOES showing mostly Cpclass flare activity in past 3 days.

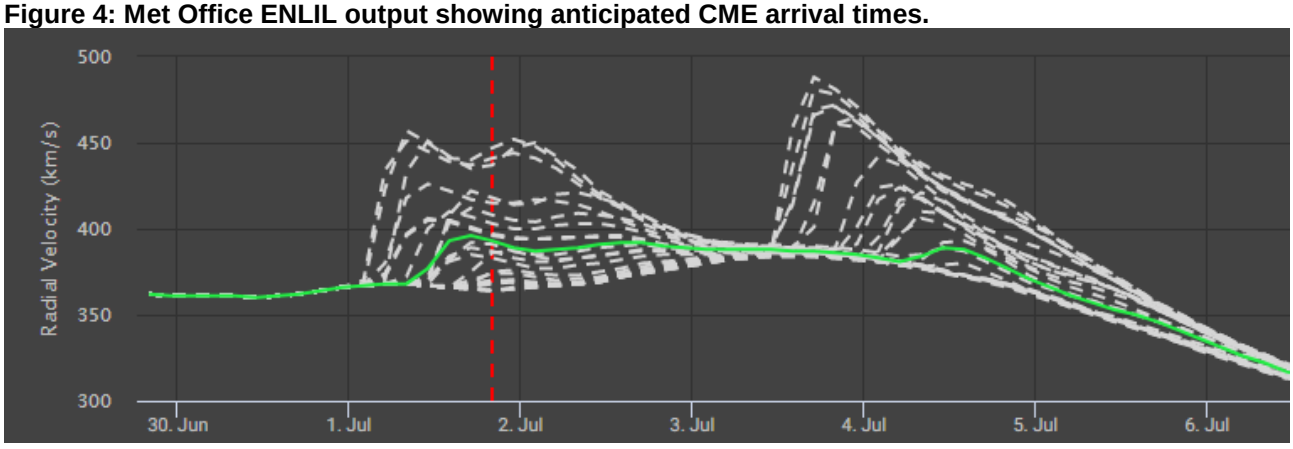


Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux, as observed by GOES16, is at background levels and is most likely to remain so throughout the period. However, there is a slight chance of S1 levels being reached due to the potential for AR3354 to produce significant flares, and given its favourable location in the western hemisphere to be magnetically connected with Earth.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	10	10	10	10
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: Met Office ENLIL output showing anticipated CME arrival times.



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High Energy Electrons Event (≥ 2MeV):
The current slightly enhanced solar wind from CH18/- will probably slowly decline in the coming days, but may be replaced by a weak enhancement from CH20/+ on day 3 (04 Jul). A continuation of flux and fluence levels near those seen at present (Moderate to diurnally High) is the most likely scenario during the forecast period, although with a gradual reduction likely later in the period. Therefore, the guidance offered by Met Office REFM is considered to be good. However, the potential arrival of the low confidence CME on day 3 (04 Jul) combined with the potential onset of CH20/+, may enhance geomagnetic activity and lower the electron cloud at a much quicker rate than indicated.

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	Yes	100	90	70	60
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	1

Figure 5: High energy electron flux at GEO and Met Office REFM output.

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